REMARKS

In view of the above amendments and the following remarks, reconsideration of the rejections contained in the Office Action of January 6, 2011 is respectfully requested.

By this Amendment, claims 1 and 11 have been amended. Thus, claims 1-30 are currently pending in the application. No new matter has been added by these amendments.

On pages 2-5 of the Office Action, the Examiner rejected claims 1, 2, 10, 11, 26, 29 and 30 under 35 U.S.C. § 102(b) as being anticipated by Allen et al. (US 4,589,927). On pages 6-9 of the Office Action, the Examiner rejected claims 12, 13 and 16-20 under 35 U.S.C. § 103(a) as being unpatentable over Chervenak et al. (US 3,322,665). Further, on pages 5-6 and 8-10 of the Office Action, the Examiner rejected claims 9, 14, 15, and 21-23 under 35 U.S.C. § 103(a) as being unpatentable over Allen or Chervenak in view of the additionally cited prior art. For the reasons discussed below, it is respectfully submitted that these claims, including independent claims 1, 2, 11 and 12, are clearly patentable over the applied prior art.

Amended independent claim 1 recites a method of producing sub-critical water decomposition products. The method of claim 1 includes continuously supplying material to be processed into a vertical reactor through an inlet provided for the reactor, whose interior is kept at a sub-critical condition for water. The method of claim 1 also includes *continuously taking out a liquid containing a decomposition product through any selected one of a plurality of outlets provided in a wall of the reactor* at different respective positions from a position where the inlet of the reactor is provided, *wherein selection of one of the outlets adjusts a distance along which the liquid containing the decomposition product flows through the reactor so as to adjust residence time of the liquid containing the decomposition product in the reactor*.

Allen discloses a process in which a liquid fluidization medium is introduced into a reactor 1 through a conduit 7, as shown in Fig. 1. Further, Allen discloses that a fine particle component is removed from the reactor 1 and is sent to a separator 9 and an external reactor 10 before being reintroduced into the reactor 1.

However, Allen does not disclose *continuously taking out a liquid containing a decomposition product through any selected one of a plurality of outlets provided in a wall of the reactor*, as required by independent claim 1.

In this regard, the Examiner notes that reference numbers 19, 11, 16 and 20 of Allen all correspond to the "plurality of outlets" of claim 1. However, it is first noted that reference

number 19 of Allen is an exhaust stack for waste gas, and is not an outlet through which a liquid containing a decomposition product is continuously taken out, as required by claim 1.

Further, Allen only discloses a single outlet at the upper portion of the reactor 1 through which a liquid is taken out. In this regard, it is noted that the reference numbers 11, 16 and 20 are all downstream branches of the conduit which is connected to the single outlet of the reactor 1, and are located entirely outside of the reactor 1, and thus conduits 11, 16 and 20 are not outlets provided in a wall of the reactor, as required by claim 1.

Therefore, as Allen only discloses a single outlet at the upper portion of the reactor 1 through which a liquid is taken out, Allen does not disclose continuously taking out a liquid containing a decomposition product through any selected one of a plurality of outlets provided in a wall of the reactor, as required by claim 1.

In addition, as Allen does not disclose a plurality of outlets provided in a wall of the reactor at different respective positions from a position where the inlet of the reactor is provided (and instead only discloses a single outlet through which a liquid is taken out), Allen also does not disclose that *selection of one of the outlets adjusts a distance along which the liquid containing the decomposition product flows through the reactor so as to adjust residence time of the liquid containing the decomposition product in the reactor*, as required by independent claim 1.

Therefore, as Allen does not disclose continuously taking out a liquid containing a decomposition product through any selected one of a plurality of outlets provided in a wall of the reactor at different respective positions from a position where the inlet of the reactor is provided, and that selection of one of the outlets adjusts a distance along which the liquid containing the decomposition product flows through the reactor so as to adjust residence time of the liquid containing the decomposition product in the reactor, it is respectfully submitted that Allen does not anticipate independent claim 1.

Independent claim 2 recites a method of producing sub-critical water decomposition products. The method of claim 2 includes continuously supplying material to be processed into a vertical reactor through an inlet provided for the reactor, whose interior is kept at a sub-critical condition for water, and *continuously taking out a liquid containing a decomposition product through any one of a plurality of outlets provided at a different position from a position where the*

inlet of the reactor is provided, to form desired steady concentration profiles of the decomposition product in the reactor. The method of claim 2 also includes taking out the desired decomposition product through at least one of the outlets, the at least one of the outlets being provided at a position where the concentration of the desired decomposition product is high.

Allen does not disclose a method which includes *continuously taking out a liquid containing a decomposition product through any one of a plurality of outlets provided at a different position from a position where the inlet of the reactor is provided, to form desired steady concentration profiles of the decomposition product in the reactor*, as required by independent claim 2.

In particular, on page 3 of the Office Action, the Examiner indicates that Allen discloses that liquid is taken from the reactor and is recirculated into the reactor, and that such recirculation facilitates "the creation of concentrations [of] the desired products in the reactor." However, regardless of whether the recirculation facilitates "the creation of concentrations," Allen does not disclose continuously taking out a liquid containing a decomposition product to form <u>**steady**</u> <u>concentration profiles</u> of the decomposition product in the reactor, as required by independent claim 2.

Rather, as indicated by the Examiner on page 3 of the Office Action, Allen discloses continuously supplying material to be processed into the reactor, taking out liquid and the fine particle component from the reactor, and recirculating the fine particle component into the reactor. Further, Allen discloses that particles in the fluid stream are free to move in random motion in all directions (column 2, lines 16-17) and that mass transport between phases is improved due to increased turbulent mixing (column 3, lines 32-33). In other words, Allen discloses that the concentration of the particles is constantly changing, that the particles are free to move randomly in all directions under turbulent conditions, and therefore Allen does not disclose continuously taking out a liquid containing a decomposition product to form <u>**steady**</u> <u>concentration profiles</u> of the decomposition product in the reactor, as required by independent claim 2.

Accordingly, as Allen does not disclose continuously taking out a liquid containing a decomposition product through any one of a plurality of outlets provided at a different position from a position where the inlet of the reactor is provided, <u>to form desired steady concentration profiles of the decomposition product in the reactor</u>, it is respectfully submitted that Allen does

not anticipate independent claim 2.

Independent claim 11 recites an apparatus for sub-critical water decomposition treatment, comprising a reactor configured to decompose material to be processed using sub-critical water, heating means for heating a mixture composed of water and the to be processed material to form and keep sub-critical conditions for water, and compressing means for compressing the mixture. Further, claim 11 recites introducing means for introducing the material to be processed into the reactor, an inlet through which the material to be processed is to be introduced into the reactor, and *a plurality of outlets provided in a wall of the reactor for letting out a mixture of a decomposition product and water from the reactor*, wherein the outlets are provided at respective positions which are different from one another in a flow direction of the sub-critical water, and which are different from a position at which the inlet is provided.

Allen does not disclose a reactor which includes *a plurality of outlets provided in a wall of the reactor for letting out a mixture of a decomposition product and water from the reactor*, as required by independent claim 11. In this regard, on page 4 of the Office Action, the Examiner indicates that reference number 19 and the "side offtake" (*i.e.*, the outlet at the upper portion of the reactor shown in Fig. 1) of Allen correspond to the plurality of outlets of claim 11.

However, as indicated above, it is noted that reference number 19 of Allen is an exhaust stack <u>for waste gas</u>, and is not an outlet <u>for letting out a mixture of a decomposition product and water from the reactor</u>, as required by claim 11. Thus, Allen only discloses a <u>single</u> outlet at the upper portion of the reactor 1 through which a liquid is taken out, and therefore Allen does not disclose a reactor which includes <u>a plurality of outlets provided in a wall of the reactor for letting out a mixture of a decomposition product and water from the reactor</u>, as required by independent claim 11.

Accordingly, as Allen does not disclose a plurality of outlets provided in a wall of the reactor for letting out a mixture of a decomposition product and water from the reactor, it is respectfully submitted that Allen does not anticipate independent claim 11.

Independent claim 12 recites an apparatus for sub-critical water decomposition treatment, comprising *a vertical reactor configured to decompose material to be processed with sub-critical water*, heating means for heating a mixture of water and the material to be processed and

compressing means for compressing the mixture, so as to form and keep a sub-critical condition for water. Further, the apparatus of claim 12 includes introducing means for introducing the material to be processed into the reactor, an inlet through which the material to be processed is to be introduced into the reactor, and an outlet for letting out a mixture of water and a decomposition product from the reactor, wherein the reactor is arranged substantially vertically and the inlet is provided for at least one of a top end portion or a bottom end portion of the reactor.

In addition, claim 12 recites that *the introduced mixture of the material to be processed and the sub-critical water is caused to flow, in the sub-critical water in a steady state, in an opposite direction to a direction in which the solid matter travels*, so as to form in the flow, in the following order from upstream of the flow, at least a fluidized bed in which the solid matter is decomposed into fine particles with the sub-critical water and the fine particles fluidize in the flow, and a sub-critical water dissolution part in which the material to be processed is turned into further finer particles or completely into a soluble material to flow with the sub-critical water, and to further form, depending on the material to be processed, a fixed bed in which solid matter stays in a fixed position even with the flow, the fixed bed being formed upstream of the fluidized bed, and wherein *a position of the outlet is adjustable so as to let out the sub-critical water dissolution part and adjust a distance through which the sub-critical water dissolution part flows*.

Chervenak discloses a device for high conversion hydrogenation of heavy gas oil which, as shown in Fig. 1, includes a fractionator 64. Chervenak also discloses that the fractionator 64 separates a liquid product into a light gas product, a naphtha product, furnace oil and heavy gas oil.

Chervenak does not disclose a vertical reactor configured to decompose material to be processed with sub-critical water, and that the introduced mixture of the material to be processed and the sub-critical water is caused to flow, in the sub-critical water in a steady state, in an opposite direction to a direction in which the solid matter travels, so as to form the fixed bed, fluidized bed and sub-critical water dissolution part as recited in claim 12. However, on page 6 of the Office Action, the Examiner indicates that the fractionator 64 of Chervenak is fully capable of performing the functions of the reactor as recited in claim 12.

In this regard, however, it is noted that the fractionator 64 of Chervenak <u>is not capable of</u>

functioning as a reactor in which *the introduced mixture of the material to be processed and the sub-critical water is caused to flow, in the sub-critical water in a steady state, in an opposite direction to a direction in which the solid matter travels*, so as to form the fixed bed, fluidized bed and sub-critical water dissolution part as required by independent claim 12.

Rather, in the response previously filed on October 21, 2010, it was argued that "although not explicitly shown in Chervenak, one of ordinary skill in the art would recognize that fractionators such as the one disclosed in Chervenak would include trays which extend from opposite walls of the fractionator in an alternating manner to define a flow path which alternates back and forth." In response to this argument, the Examiner notes in item 32 of the Office Action that Chervenak does not discuss the presence of trays within the fractionator.

It is acknowledged that Chervenak does not explicitly disclose trays within the fractionator. Nevertheless, it is respectfully submitted that one of ordinary skill in the art would recognize that fractionators such as the one disclosed in Chervenak would include trays. In support of this argument, Applicant submits the attached excerpt from a Japanese textbook on separation techniques (with an English translation of the relevant portions) as evidence that fractionators (such as that of Chervenak) include trays which extend from opposite walls of the column in an alternating manner and form a cascading flowpath, as shown in Figs. 2.17, 2.18 and 2.22 of the attached documents.

Thus, if the fractionator 64 of Chervenak were used as a vertical reactor configured to decompose material to be processed with sub-critical water, the fractionator 64 of Chervenak <u>would not be capable</u> of allowing *the introduced mixture of the material to be processed and the sub-critical water to flow, in the sub-critical water in a steady state, in an opposite direction to a direction in which the solid matter travels, so as to form the fixed bed, fluidized bed and sub-critical water dissolution part*, as the series of plates which would be arranged within the fractionator 64 of Chervenak would create a flowpath that would substantially impede the ability of the mixture of the material to be processed and the sub-critical water to flow in a steady state in an opposite direction to a direction in which the solid matter travels, and that would significantly reduce the ability for the fixed bed, fluidized bed and sub-critical water dissolution part to be formed in the specific manner recited in claim 12.

Further, as noted by the Examiner on page 7 of the Office Action, Chervenak does not disclose a compressing means for compressing the mixture in the fractionator. In this regard, the

Examiner notes that Chervenak discloses the use of a pump on the recirculating line, and concludes that it would have been obvious to one of ordinary skill in the art to use a pump in order to pressurize the contents of the fractionator.

However, even if the fractionator were modified to include a pump as suggested by the Examiner, it is noted that, for the reasons discussed above, the fractionator of Chervenak would still not be capable of performing the functions of a reactor in which *the introduced mixture of the material to be processed and the sub-critical water is caused to flow, in the sub-critical water in a steady state, in an opposite direction to a direction in which the solid matter travels*, so as to form the fixed bed, fluidized bed and sub-critical water dissolution part as required by independent claim 12.

Accordingly, it is respectfully submitted that it would not have been obvious to one of ordinary skill in the art to modify the device of Chervenak so as to result in or render obvious the invention of independent claim 12.

In addition, it is respectfully submitted that the additional prior art references applied by the Examiner do not cure the defects of the Allen and Chervenak references as discussed above.

Further, on page 11 of the Office Action, the Examiner indicates that claims 3-8, 24, 25, 27 and 28 are allowed. As no amendments have been made to claims 3-8, 24, 25, 27 and 28, it is respectfully submitted that these claims remain allowed at least for the reasons indicated by the Examiner.

Therefore, it is respectfully submitted that independent claims 1-4, 11 and 12, as well as claims 5-10 and 13-30 which depend therefrom, are clearly allowable over the prior art of record.

In view of the foregoing amendments and remarks, it is respectfully submitted that the present application is clearly in condition for allowance. An early notice to that effect is respectfully solicited.

If, after reviewing this Amendment, the Examiner feels there are any issues remaining which must be resolved before the application can be passed to issue, the Examiner is respectfully requested to contact the undersigned by telephone in order to resolve such issues.

Respectfully submitted,

Hiroyuki YOSHIDA

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May 6, 2011

そこが
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化学
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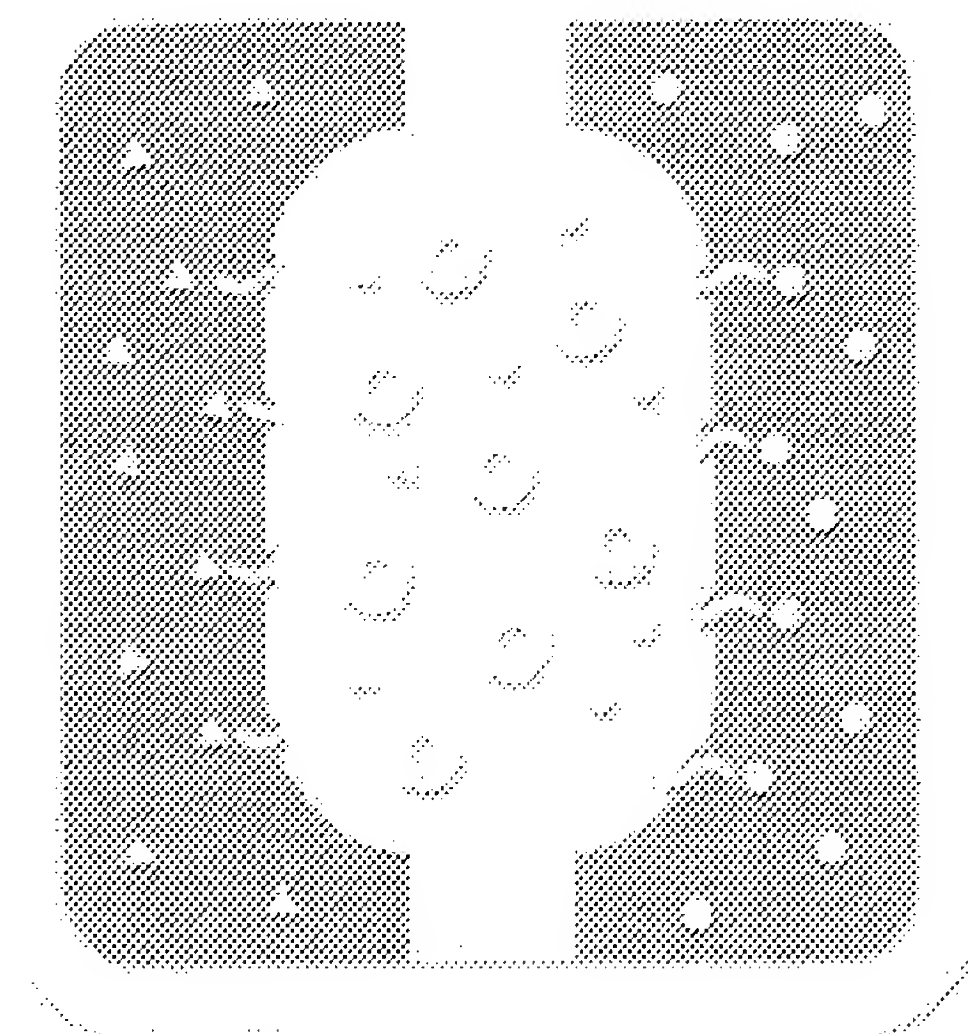

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そのときの物質収支と気液平衡関係は次式のようになる。ただし、F は原料量、V は蒸気量、L は液量を表す。

全体の物質収支 $F=L+V$ (2.2.17)

成分の物質収支 $Fz_i=Lx_i+Vy_i$ (2.2.18)

気液平衡関係 $y_i=K_ix_i$ (2.2.19)

ここで、K_i は気液平衡定数である。

また、各成分の組成の間には次の関係がある。

$$\sum_i z_i=1 \quad \sum_i x_i=1 \quad \sum_i y_i=1 \tag{2.2.20}$$

式(2.2.17)～(2.2.20) より次式が導かれる。

$$\sum_i \frac{z_i(1-K_i)}{K_i(V/F)+(1-V/F)} \tag{2.2.21}$$

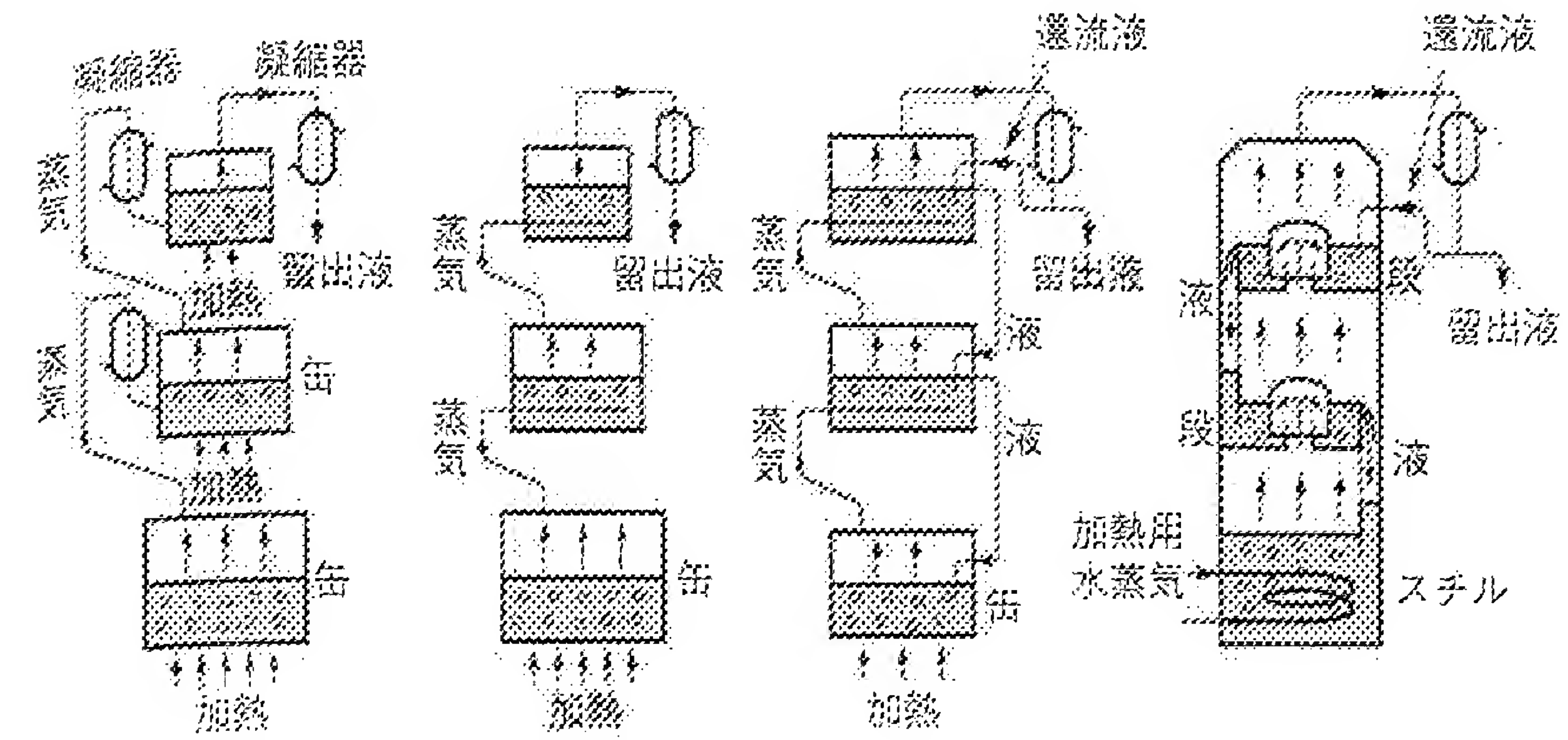
ここで、V/F はフラッシュ率と呼ばれ、式(2.2.21) において $V/F=0$ とすれば沸点計算になり、$V/F=1$ のときは露点計算になる。また、温度と圧力を規定すれば V/F すなわち気液の量（または量比）が計算できる。

2.2.6 再蒸留とバッチ精留

単蒸留やフラッシュ蒸留で得た留出液を再び単蒸留やフラッシュ蒸留すれば、低沸点成分の濃度はさらに高くなる。この操作を再蒸留という。再蒸留を何回もくり返せば低沸点成分はいっそう濃縮されるが、留出液は1回ごとに少なくなり、手間もかかるし、加熱と冷却をくり返すので熱も無駄になる（図2.15)。

図中（a）は再蒸留（単蒸留の3回くり返し）をモデルで表したものである。(b) は（a）を改良した方法で、蒸気を次の缶の液に直接吹き込んで蒸気を凝縮させ、そのとき出る潜熱で液を沸騰させる。そのため、加熱と冷却はそれぞれ1回だけですむ。

図中（b）の方法では、最初は第2、第3の缶に液が入っていないので、第1の缶だけに液を入れて加熱をしても蒸気は第2、第3の缶を素通りし（熱損失による分縮が起こり、液が少しは溜まるが)、再蒸留は行われない。



(a) 再蒸留 (b) 再蒸留の改良 (c) 精留 (d) 段塔によるバッチ精留

図2.15 再蒸留から精留へ

そこで、図中（c）のように凝縮液の一部を留出液としてとり出し、残りを第3の缶に戻してやる。この操作を還流という。そして、第3の缶にある程度液が溜まったら、順次下の缶に液を流下させる。このようにすれば、各缶に液が溜まるから再蒸留が行われる。

還流を行う蒸留のことを精留という。図中（d）は（c）の各缶を積み重ねて1つの塔の形にしたもので、各缶に当たるものを段といい、段で構成された塔を段塔という。なお、(d) のような精留（バッチ精留）では、留出液をとり出すにつれて、留出液および各段の液の低沸点成分濃度は低下する。したがって、ある程度留出液が得られたところで操作を打ち切ることになる。

2.2.7 連続精留

バッチ精留（図2.15の（d)）の加熱を行う部分の液は原液よりも低沸点成分の濃度が低くなっている。いま、仮に上から2段目の段の濃度が原液の濃度と同じになっているとすれば、その段に原液を少しずつ追加し、スチル（缶）の液を少しずつ抜き取ることによって、留出液および各段の液量も濃度も変化しなくなり、精留をいつまでも続けることができる。このような精留を連続精留（あるいは連続蒸留）といい、大規模な蒸留はすべてこの方法で行われてい

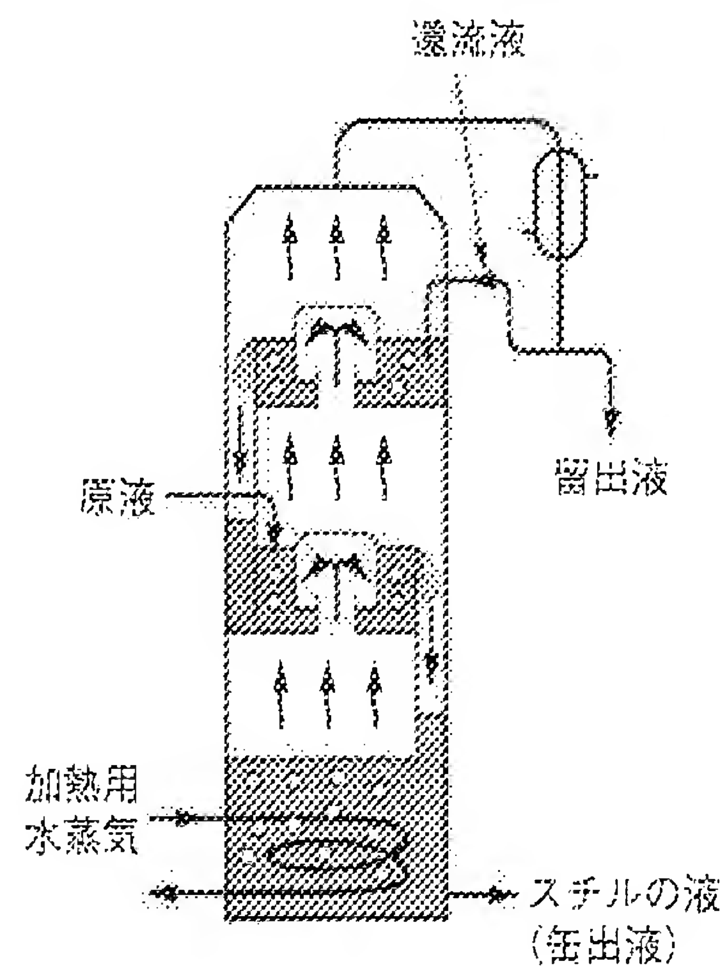


図 2.16 連続精留

る（図 2.16）。

連続精留装置の構成を図に示す（図 2.17）。高濃度の工業用エタノールを得る場合を例にして、その操作の概要を説明しよう。

原料のエタノール溶液は精留塔の中央部に供給され、塔底にあるリボイラーで熱が与えられる。そして、塔頂から出た蒸気は凝縮器で冷やされて液化し、エタノールが高濃度に濃縮された留出液として抜き出され、留出液の一部は還流液として精留塔の上部に戻される。一方、塔底からはエタノールをほとんど含まない残液（水）が塔底液（缶出液）として抜き出される。

精留塔の中には多数の棚段（トレイ）が設けられている。トレイにはいろいろな種類があるが、最も一般的なのは多孔板（シーブトレイという）である（図 2.18）。

シーブトレイには、蒸気が上がっていく多数の小孔と、液を落とす下降管（ダウンカマー）がついている。そのため、リボイラーで熱せられて蒸発した気相は小孔を通過し、トレイ上の液相中を小さな泡となって上昇する。それによって、気相と液相が十分に接触され、この接触の間に蒸気の一部は液化し、この液化の際に放出する凝縮熱で液の一部が逆に気化する。この結果、トレイ

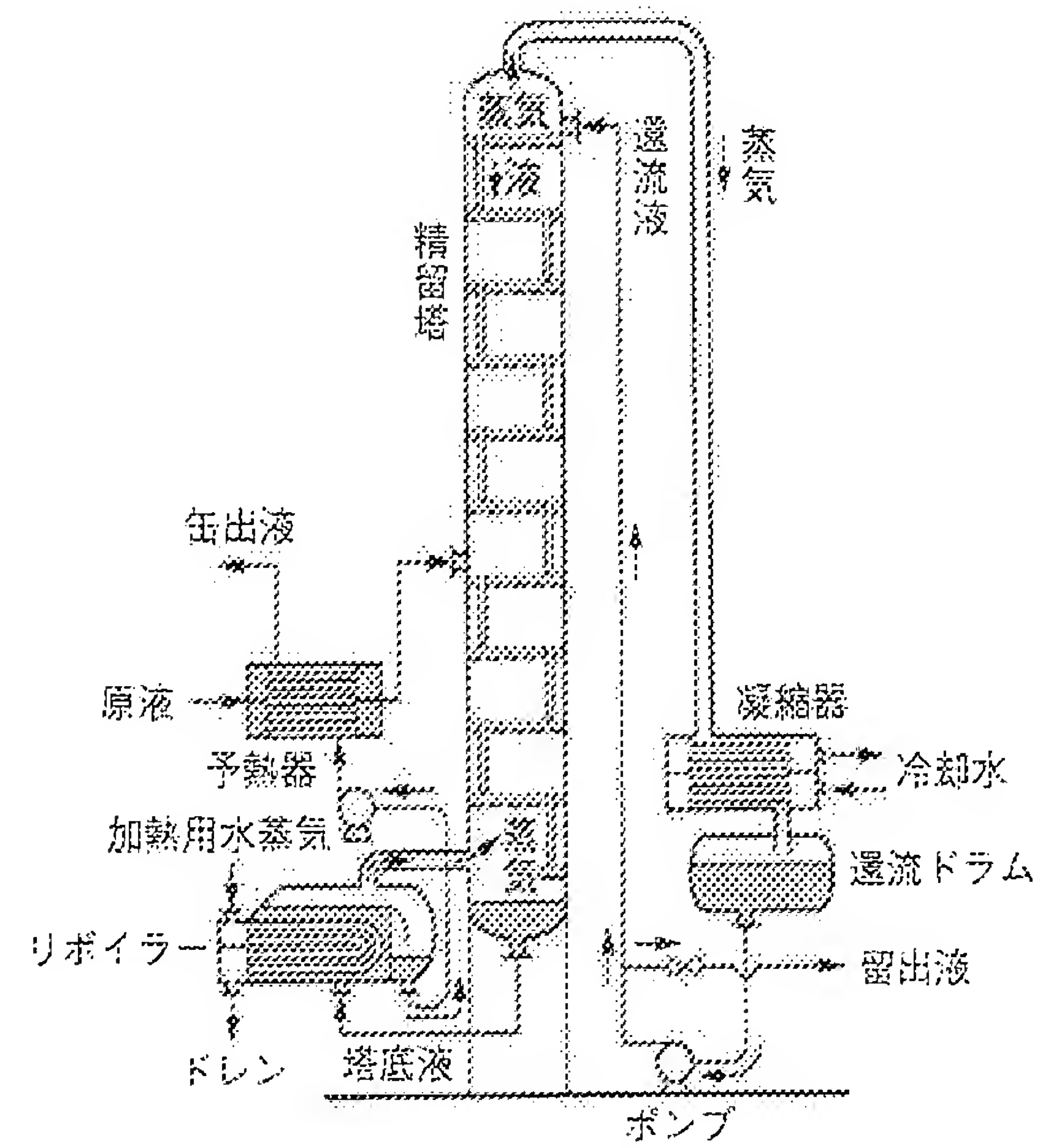


図 2.17 連続精留装置

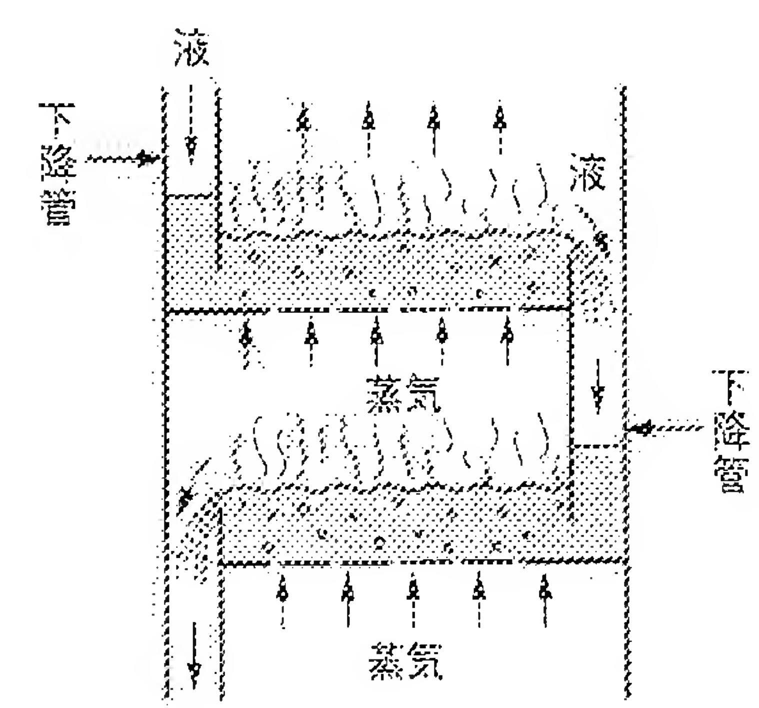
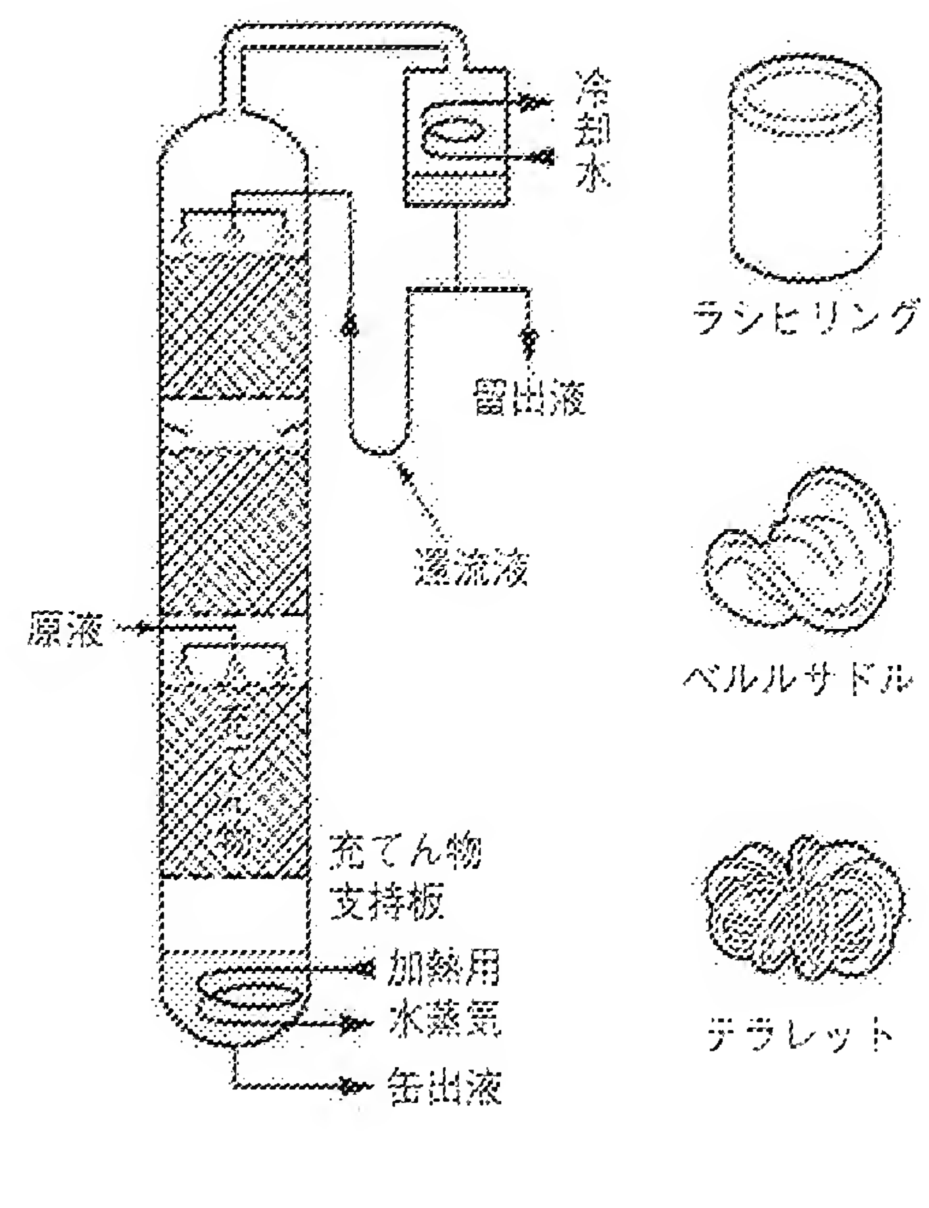


図 2.18 トレイ上での気液の接触

を去る蒸気はトレイに入ってくるときよりも低沸点成分が濃縮され、液のほうは高沸点成分が濃縮される。

トレイごとにこのような部分的な相変化が起こるので、精留塔の塔頂では低沸点成分が高度に濃縮され、塔底では高沸点成分が高濃度になる。



(a) 充てん塔　　(b) 充てん物

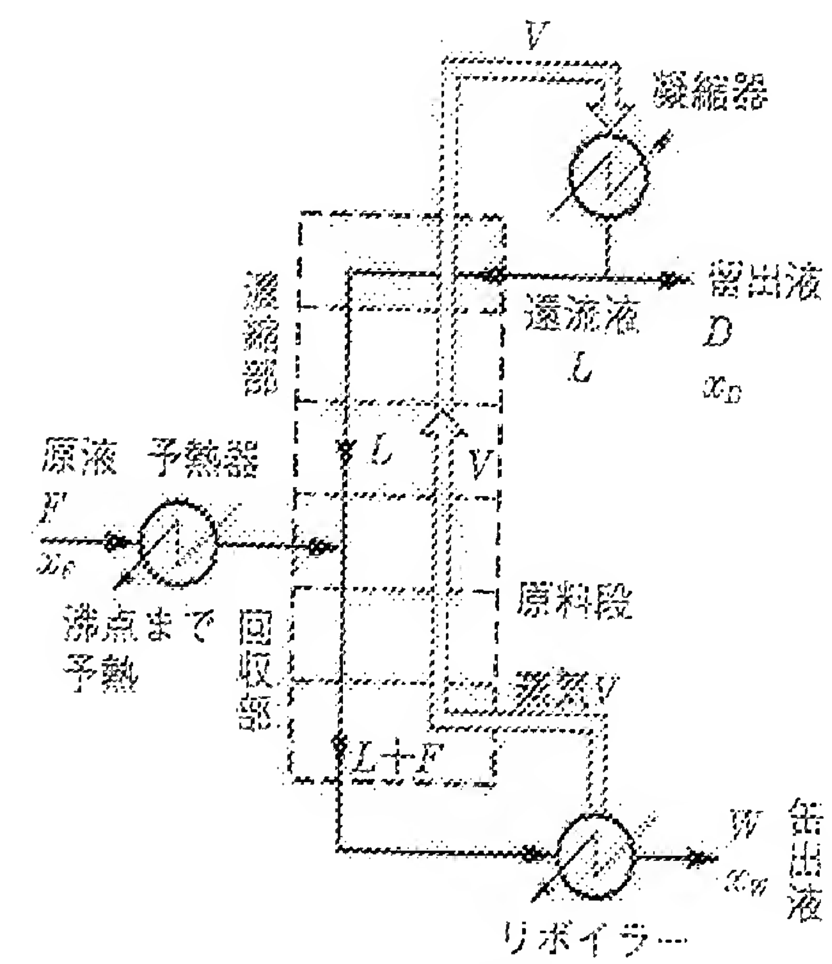
図 2.19　充てん塔と充てん物

トレイ上で気液が接触し物質と熱の移動が起こるためには、塔頂から液が流れ落ちてくることが必要であり、このために還流という操作が欠かせないのである。なお、トレイの代わりに金網や陶器などでできた充てん物を用いる蒸留塔（充てん塔という）もある（図 2.19）。

連続精留装置について物質収支を調べ、目的とする濃度の留出液を得るのに必要な段数と還流比を決める基礎的関係を導くことにしよう。ただし、原料は2成分系の液体混合物とし、沸点まで予熱されて原料段に供給されるものとする（図 2.20）。

原料段より上の部分を濃縮部、下の部分を回収部というが、まず濃縮部の物質収支を、塔頂部を含めて考えると、

全体の物質収支　$V=L+D$　(2.2.22)



F、D、W、V、L：流量 [kmol/h]
x_F、x_D、x_W：低沸点成分のモル分率

図 2.20　連続精留塔の物質の流れ

成分の物質収支　$Vy_{n+1}=Lx_n+Dx_D$　(2.2.23)

ここで、y は蒸気中の低沸点成分の組成、x は液中の低沸点成分の組成である。また n は段の位置を表し、最上段から下に向かって第1段、第2段、…と呼ぶことにする。

式(2.2.22) と式(2.2.23) から V を消去すると次式が導かれる。

$$y_{n+1}=\frac{L}{L+D}x_n+\frac{D}{L+D}x_D \quad (2.2.24)$$

還流比を R で表し $R=L/D$ とおくと、式(2.2.24) は次式となる。

$$y_{n+1}=\frac{R}{R+1}x_n+\frac{1}{R+1}x_D \quad (2.2.25)$$

式(2.2.25) は任意の段（第 n 段）の液組成 x_n と、その段に下から上がってくる蒸気の組成 y_{n+1} との関係を表す。そして、留出液の組成 x_D と還流比 R が決まれば、x-y 線図上では傾きが $R/(R+1)$ の直線となる。このような直線を操作線といい、濃縮部の操作線を特に濃縮線という。

こんどは回収部の物質収支を、塔底部を含めて考えると、

全体の物質収支　　$L+F=V+W$　　(2.2.26)

成分の物質収支　　$(L+F)x_m=Vy_{m+1}+Wx_W$　　(2.2.27)

したがって、次式が導かれる。

$$y_{m+1}=\frac{V+W}{V}x_m-\frac{W}{V}x_W=\frac{R'+1}{R'}x_m-\frac{1}{R'}x_W \qquad (2.2.28)$$

ただし、$R'=V/W$ であって、これを回収比という。

式(2.2.28) は任意の段（第 m 段）の液組成 x_m と、その段に下から上がってくる蒸気の組成 y_{m+1} との関係を表す回収部の操作線であり、缶出液の組成 x_W と回収比 R' が決まれば、x–y 線図上では傾きが $(R'+1)/R'$ の直線となる。このような回収部の操作線を回収線という。

濃縮線と回収線を x–y 線図上に描き、留出液の組成 x_D を起点にして平衡線と操作線を交互に使いながら階段状に作図をすれば、各段の気液の組成と段数（理論段数）を求めることができる（図 2.21）。これをマッケーブ・シール法の階段作図という。

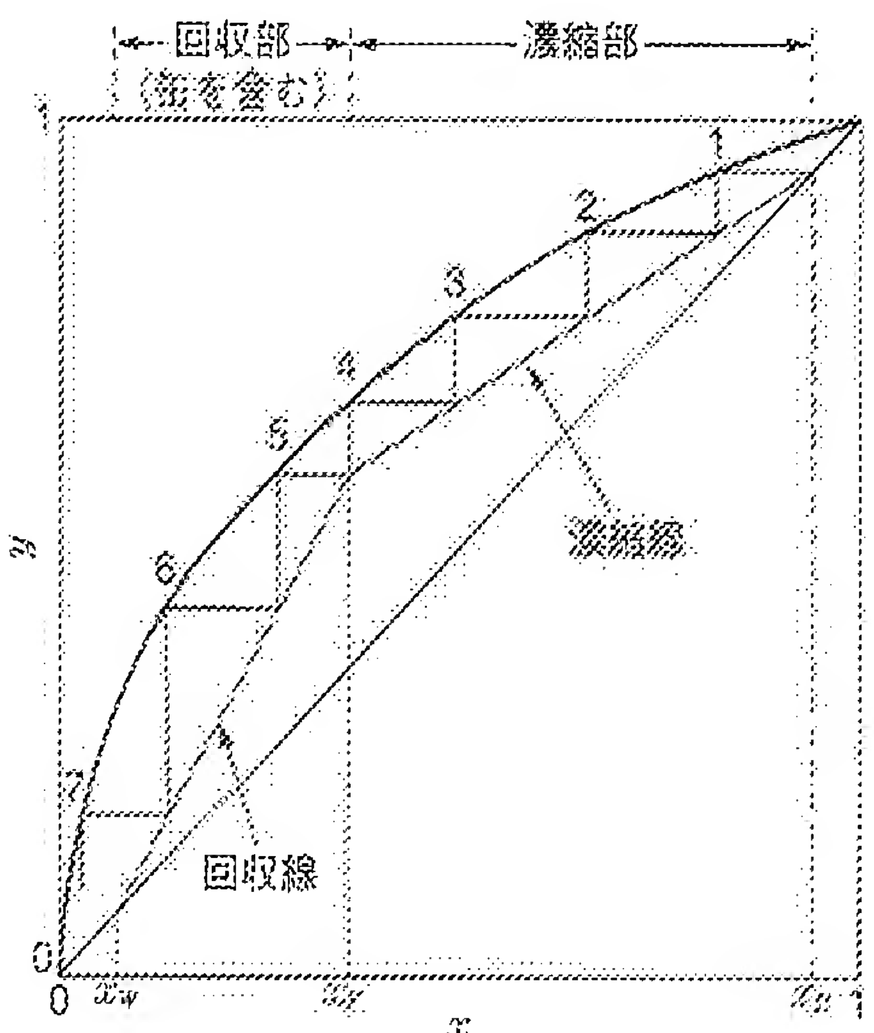


図 2.21　階段作図の例

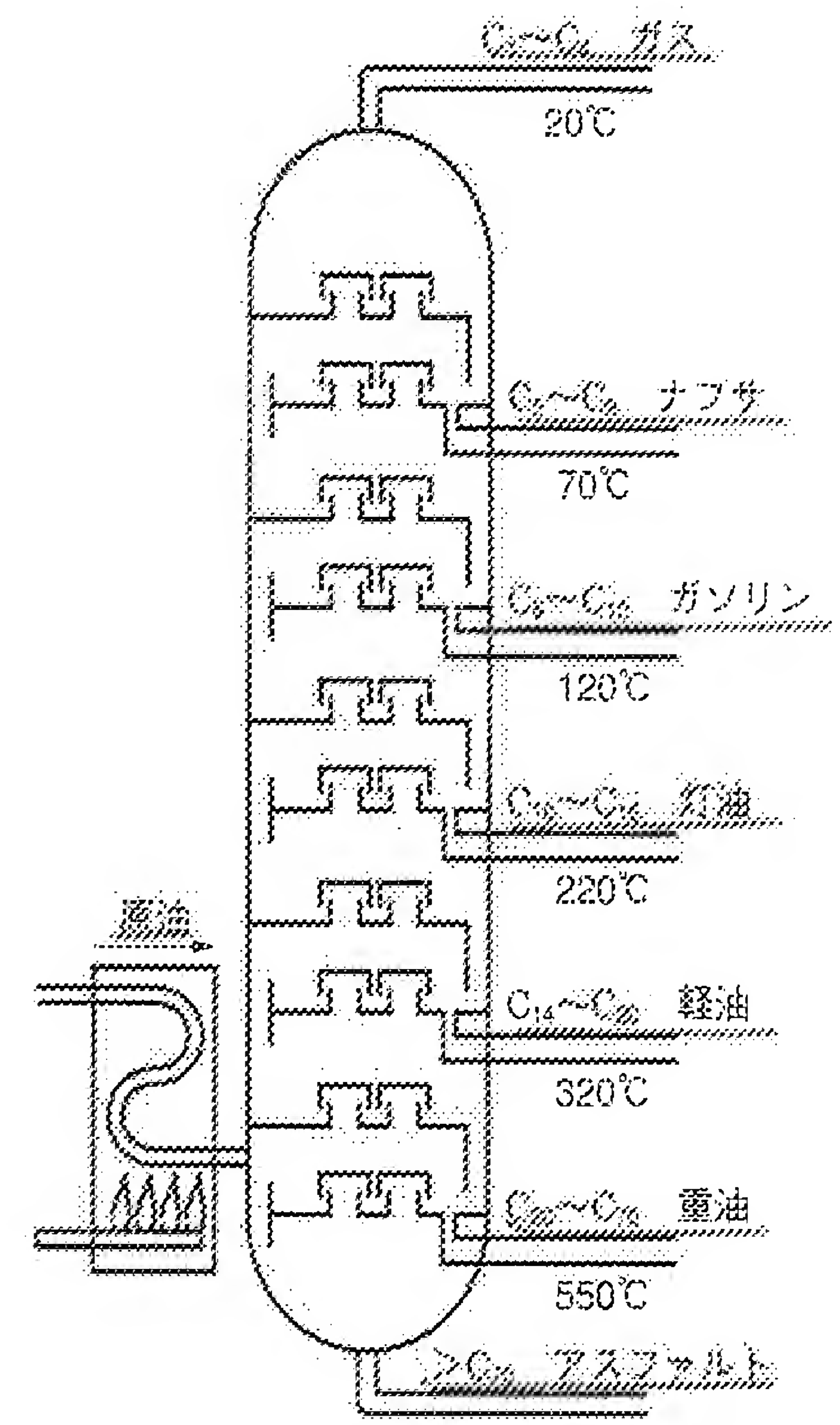


図 2.22　原油の分留

工業的な蒸留の代表例は原油の分留である。原油は非常に多くの種類の炭化水素を含んでおり、各々の成分を1つずつ分けるのは大変であるばかりでなく、その必要もない。それよりも、化学製品の原料や燃料として用いるために、ある沸点範囲（留分）ごとに何種類かに粗分けすることに意味がある。そのため、原油の蒸留では塔頂と塔底からだけではなく、塔の中間部の何カ所からも液を抜き出す（図 2.22）。

原油の分留における各留分の沸点範囲は、用いる原油の種類や装置の特徴によって違いがあるが、おおよそ次のようである。

随伴ガス	30℃ 以下
ガソリン	30～190℃

灯油	180～250℃
軽油	230～400℃
重油	380℃ 以上

2.2.8 共沸蒸留

異種分子の間で分子間力が大きく異なり、混合物の蒸気圧が変化することによって、平衡状態にある液相の組成と気相の組成がまったく同じになることがある。この現象を共沸と呼んでいる。たとえば、エタノール水溶液は 1 atm においてエタノール 96 wt%で共沸するが、このときの温度は 78.2℃ であり、水の沸点よりもエタノールの沸点（78.3℃）よりもさらに低くなる。このように、混合物を形成している最も沸点の低い成分の沸点よりも低い温度で共沸することを最低共沸といい、そのような混合物を最低共沸混合物という。

これとは逆に、各成分の沸点よりも上がったような共沸も存在し、これを最高共沸といい、そのような混合物を最高共沸混合物という。この例としては、アセトン―クロロホルム系やフェノール―ピリジン系などがあり、異種分子の間で新たな水素結合がつくられ、もとの同種分子間力よりも強い分子間力が形成されるときに起こる。ただし、分離に利用されることは少ない。

エタノール水溶液を蒸留した場合、塔の上部でエタノールが共沸組成の 96 wt%になると共沸が起こり、気相も液相もそれ以上に濃度が変化しなくなる（図 2.23）。つまり、比揮発度が 1 になって、通常の蒸留法ではこの組成を越える濃度にまで濃縮することが不可能になる。

共沸組成を越えた濃度にまで濃縮する蒸留法が共沸蒸留である。最低共沸を形成する成分 A と B の溶液から共沸組成以上に成分 A を濃縮するには、その共沸温度よりもさらに低い温度で成分 A と共沸するような第 3 成分 C を加え、成分 A と C の共沸混合物をまず成分 B から分離する方法である。あるいは、成分 A と B と C の 3 成分共沸混合物をつくって、これをまず成分 B から分離する方法もある。

純粋なエタノールを得るには普通は後者の方法が用いられる。第 3 成分（添

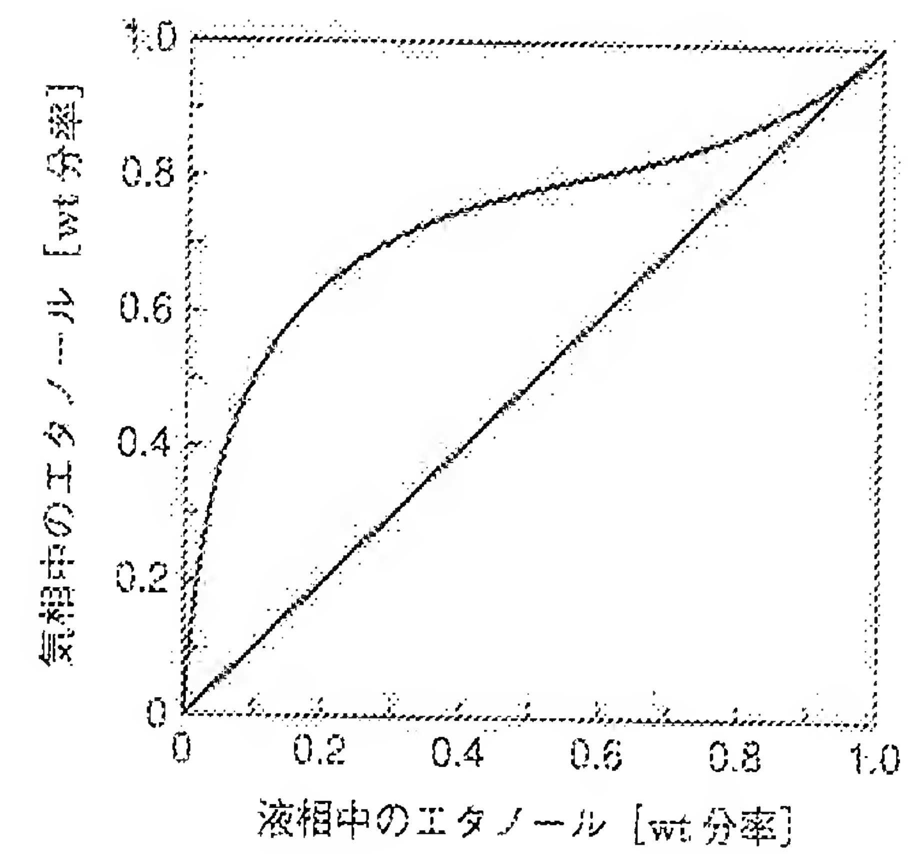


図 2.23 エタノール―水系の気液平衡

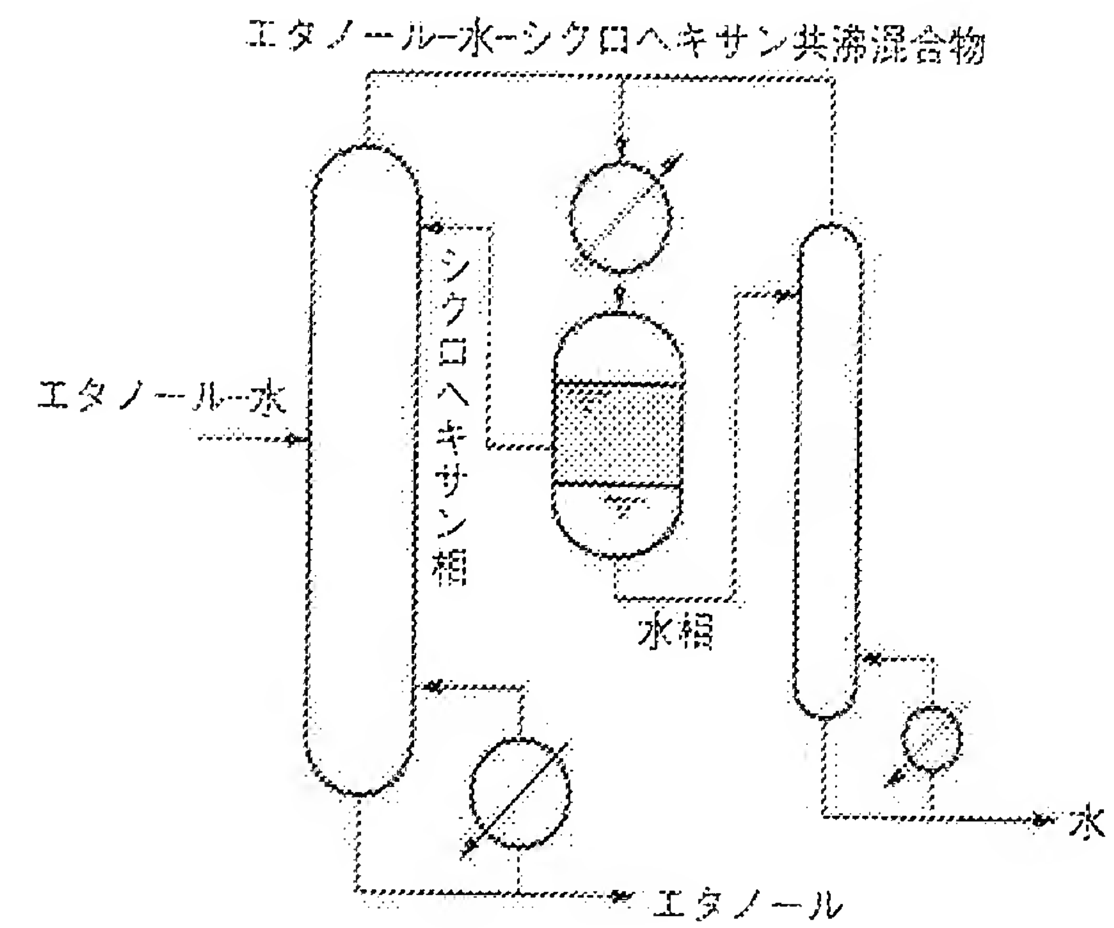


図 2.24 共沸蒸留プロセス（無水エタノールの製造）

加剤あるいは共沸剤と呼ぶ）として、シクロヘキサン、ベンゼン、ペンタンなどが一般的である。ここでは、シクロヘキサンを用いる無水エタノール製造のための共沸蒸留プロセスを説明しよう（図 2.24）。

第 1 塔には共沸組成まで濃縮されたエタノール水溶液が供給される。塔頂からエタノール―水―シクロヘキサンの 3 成分共沸組成の蒸気が発生し、塔底か

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[page 61 (line: 10)]

2.2.7 Continuous Rectification

[page 62 (line: 9-11)]

A plurality of trays is provided inside the rectification column. There are various trays, and the most general one is a porous plate (referred to as a sieve tray) (Fig.2.18).

[page 63]

Fig.2.18 Gas-liquid contact on the tray

[page 67(line: 1)- page 68(line: 3)]

A representative example of industrial distillation is a fractionation of crude oil. Since crude oil contains an extremely many kinds of carbon hydrides, it is hard to separate compositions of each one by one and even more, there is no necessity thereof. Other than that, it is more meaningful to categorize compositions into some kinds roughly at every given range of a boiling point (fraction) in order to use compositions as a raw material or fuel of

chemical products. For this purpose, in a distillation of crude oil, liquid is drawn not only from the top and bottom of the column, but also from the some parts in the middle of the column (Fig.2.22).

The range of the boiling point of each fraction in a distillation of crude oil is different depending on a kind of crude oil to be used or a characteristic of a device, the range is approximately as follows.

Associated gas: 30°C or less

Gasoline: 30 to 190°C

Kerosine: 180 to 250°C

Light oil: 230 to 400°C

Heavy oil: 380°C or more

[page 63]

Fig.2.22 A fractionation of crude oil

Left side of the Fig.2.22: Crude oil

Right side of Fig.2.22 (from above): C1-C4 Gas

C5-C9 Naphtha

C5-C10 Gasoline

C10-C16 Kerosine

C14-C20 Light oil

C20-C70 Heavy oil

>C70 asphalt

Colophon

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